

Eye-Tracking in Practice: The EyeTrackR R Package and its Use in a Study on Human Postures

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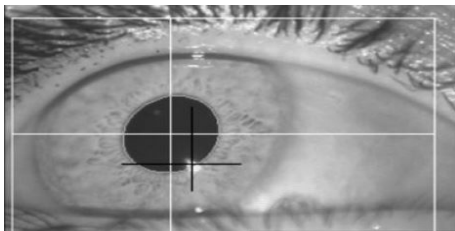


Outline

- 1 Eye-Tracking & EyeTrackR R Package
- 2 The Posture Study
- 3 EDA
- 4 Syrjala Test & Analysis
- 5 Conclusions and Outlook

Development

- Eye trackers first built in the late 1800s.
- Eye tracking techniques developed rapidly during the past century.
- Video-based pupil and corneal reflection tracking method are the dominating eye tracking method since early 1990s.



The identified pupil (white cross-hair) and corneal reflection (black cross-hair).
(Previously published in Holmqvist et al. 2011).

Applications

- **Education:** Solving problems, classroom presentations, reading, and looking at graphics.
- **Usability Research:** Reading behaviors online, searching, scanning online information, and web page design.
- **Sports:** Studying basic technical mistakes in hand-eye coordination and how to optimize performance in soccer, table tennis, shooting, hockey, and baseball.
- **Psychology:** Understanding how people gather information visually and how information is processed, e.g., research in autism.
- **Marketing:** Understanding of consumers' willingness to purchase the goods.

Mobile Eye Tracker



Data Recording



Data from static eye tracker. (Previously published in Holmqvist et al. 2011)



Data from mobile eye tracker.

Shooting Scene No.1



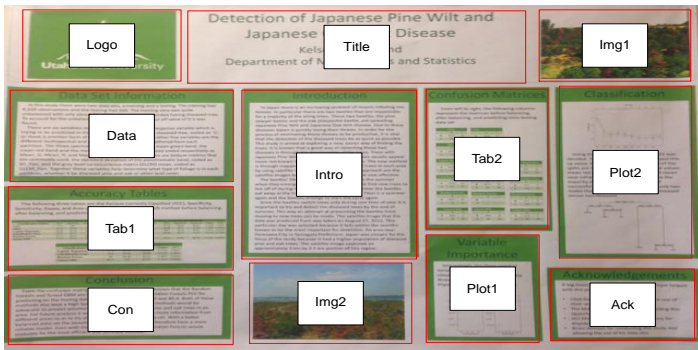
Shooting Scene No.2



Data Recorded

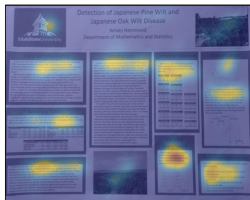
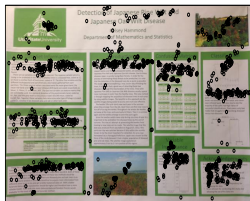
- Show eye-tracking video.

Areas of Interest (AOI)



Defined AOIs in R

Scatterplot, Heatmap & Linked Microposter Plot



Cumulative Microposters



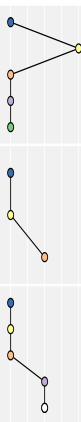
Areas of Interest

- Ack
- Con
- Plot1
- Plot2
- Tab2
- Tab1
- Intro
- Data
- Img1
- Img2
- Logo
- Title
- Blank

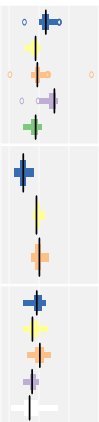
Length of Visits (sec)



Number of Visits



Pupil Radius in Pixels



Functions in the **EyeTrackR** R Package ¹

Function Name	Functionality Group
(i) Data Processing	
<i>GetVideoFrames</i>	Break AVI format video into individual frames.
<i>ExtractCoordinates</i>	Extract x and y coordinates in terms of the poster.
(ii) Data Summarization	
<i>ResizeImg</i>	Convert an input image into a user specified size.
<i>DrawAOIs</i>	Create rectangular AOIs and name the AOIs.
<i>GetAOITimelineData</i>	Categorize the coordinates by the visits of each AOI.
<i>GetPosterData</i>	Categorize the coordinates by each AOI.
(iii) Common Eye Tracking Visualization Tools	
<i>DrawEyeDotplot</i>	Create a dot plot indicating time spent on each AOI.
<i>DrawEyeBoxplot</i>	Create a box plot showing pupil radiuses in each AOI.
<i>DrawEyeBarplot</i>	Create a bar plot indicating time spent on each AOI.
<i>DrawEyeScatterplot</i>	Create a scatter plot showing focus points.
<i>DrawEyeHeatmap</i>	Create a heat map with Gaussian kernel function.
<i>DrawEyeAOITimelines</i>	Create an AOI timeline plot.
<i>DrawEyeScanpathMap</i>	Create a scanpath map.
(iv) Linked Microposter Plots	
<i>DrawEyeLMPlot</i>	Create a linked microposter plot. ²
<i>DrawEyeLTMPPlot</i>	Create a linked timeline microposter plot.
<i>DrawEyeLSMPlot</i>	Create a linked scanpath microposter plot.

¹ See Li (2017) & Li and Symanzik (2017) for details.

² See Li and Symanzik (2016) for details.

Primary Research Question

- Does judging the action capabilities of another person depend on one's own experiences?
- Background: Action anticipation must be present when interacting with others (e.g., to avoid collisions, pass something on to someone, etc.).
- Motivated by research in the Kinesiology and Health Science Department at Utah State University (USU).

Participants

- Group 1: 20 students with minimal experience with actions that require stability (e.g., yoga, gymnastics, . . .) from the undergraduate psychology student pool at USU.
- Group 2: 20 students with extensive yoga experience from advanced yoga classes at USU.
- Data collection still ongoing. Preliminary results presented here.
- See Symanzik et al. (2017 & 2018), for details.

Anticipated Outcomes

- Those with extensive yoga experience will judge an actor to be more stable than those without stability-specific experience.
- **The visual information (i.e., viewing patterns) used to judge stability will differ between different groups of individuals with unique action experiences.**

Apparatus and Tasks

- 22 pictures of a single actor holding a posture.
- All postures shown to each participant in random order.
- Participants have to judge the stability of each posture, i.e., how long the person could hold the posture.
- Participants wear an ASL portable eye-tracking device that records the viewing patterns.
- Extract information from the eye-tracking videos via the *EyeTrackR* R package (Li, 2017).

Postures 1 to 6 (out of 22)



Statistical Analysis

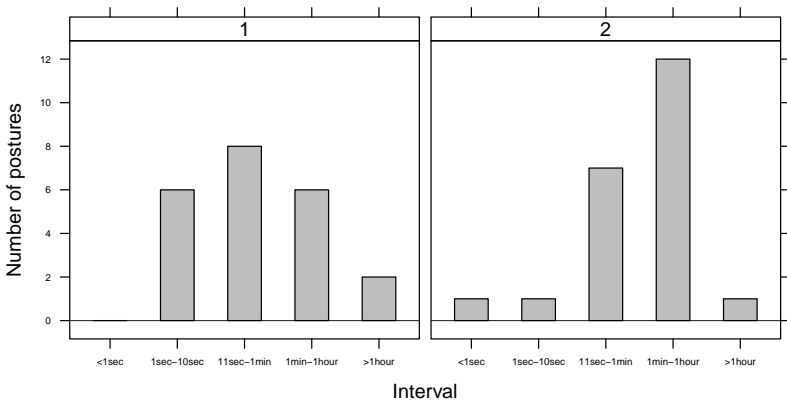
- What are **within groups** similarities /differences (if any) of the viewing patterns for each posture / for all postures?
- What are **between groups** similarities / differences (if any) of the viewing patterns for each posture / for all postures?

Results for Two Test Participants

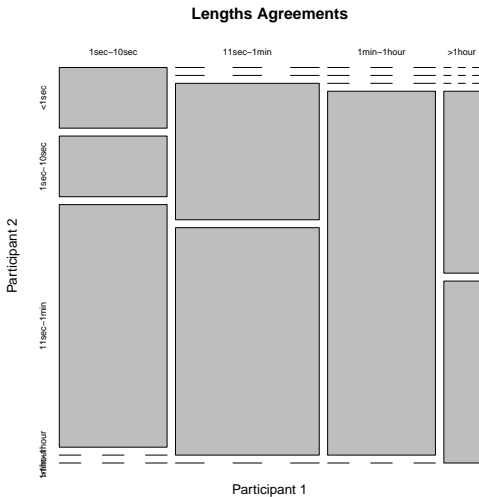
- Agreement on stability assessment in 50% of postures (11 out of 22)
- 1 level difference for remaining 50% of postures

Stability Assessment Distributions

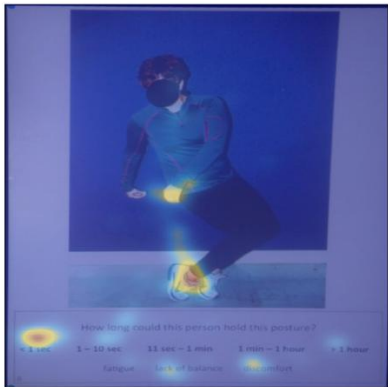
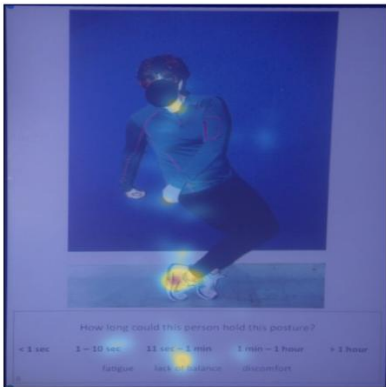
Lengths Assessments by Participant



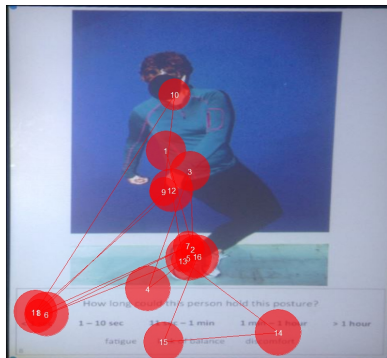
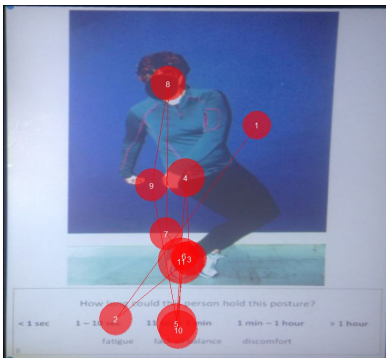
Stability Assessment Comparison



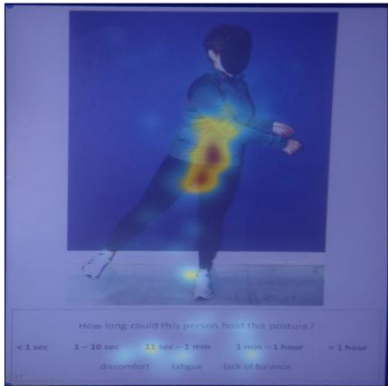
Posture 8: 1sec-10sec vs <1sec, but similar viewing patterns [Heatmaps]



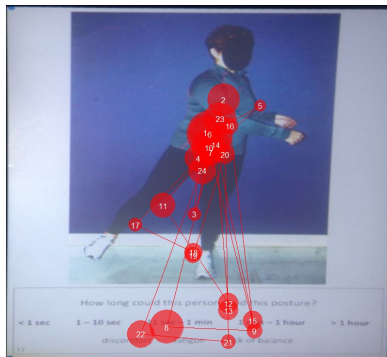
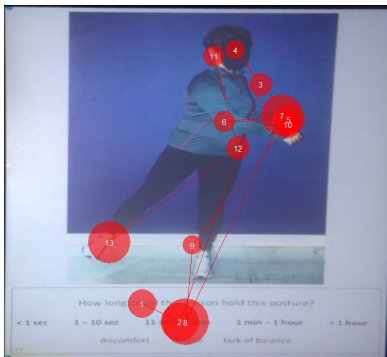
Posture 8: 1sec-10sec vs <1sec, but similar viewing patterns [Scanpaths]



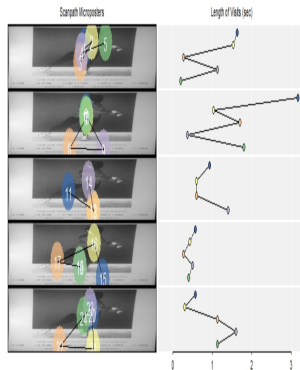
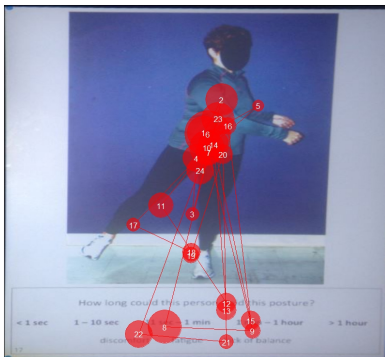
Posture 17: 11sec-1min vs 1min-1hour, and different viewing patterns [Heatmaps]



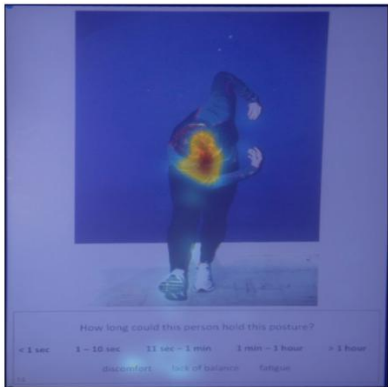
Posture 17: 11sec-1min vs 1min-1hour, and different viewing patterns [Scanpaths]



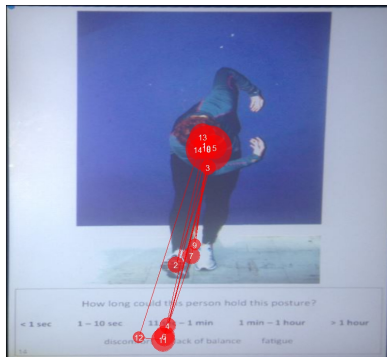
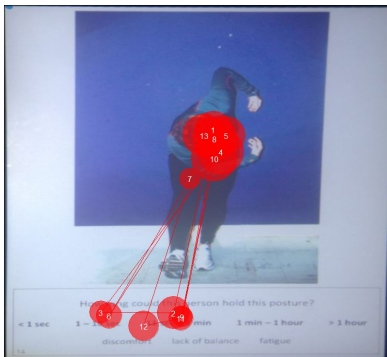
Posture 17: Scanpaths vs Linked Scanpath Microposter



Posture 14: 11sec-1min (both) and similar viewing patterns [Heatmaps]



Posture 14: 11sec-1min (both) and similar viewing patterns [Scanpaths]



The Syrjala (1996) Test

- Tests for a difference between the spatial distributions of two populations.
- Sensitive to differences in the way the populations are distributed across the study area.
- Insensitive to differences in abundance between the two populations.
- Frequently used for wildlife sample surveys and epidemiology; rarely used for eye-tracking so far (e.g., Chetverikov et al., 2018).
- Here: Applied to the viewing patterns from pairs of participants using 5×5 , 10×10 , and 20×20 **grids** and 25, 100, and 400 **random point locations** obtained from a sequential spatial inhibition (SSI) process.

Posture A: Scatterplots of Viewing Patterns



Posture B: Scatterplots of Viewing Patterns



Posture C: Scatterplots of Viewing Patterns



Posture D: Scatterplots of Viewing Patterns



Syrjala's Test Results for Postures A through D

Posture	Type of Data Conversion					
	Grid			Random Points		
	5 × 5	10 × 10	20 × 20	25	100	400
A	0.279	0.057	0.008	0.164	0.066	0.013
B	0.618	0.554	0.310	0.758	0.418	0.334
C	0.015	0.001	0.001	0.009	0.002	0.001
D	0.238	0.109	0.018	0.170	0.095	0.042

- Statistically significant differences in viewing patterns ($p \leq 0.05$) shown **in bold**.
- P-values tend to get smaller as the number of grid cells / random points increases, but this is not monotonic.

Revisiting Posture C: Scatterplots of Viewing Patterns



Revisiting Posture B: Scatterplots of Viewing Patterns



Interpretation of Syrjala's Test Results

- Results of Syrjala's test highly depend on type of data conversion (grid vs. random points) and number of grid cells or number of random cells, respectively.
- A total of 144 tests [= (22 postures + 2 test images) × 6 data conversions] for each pair of participants conducted:
 - Minimum number of significant test outcomes: 8 ($\approx 6\%$) — This could be by chance.
 - Maximum number of significant test outcomes: 43 ($\approx 30\%$) — This is no longer by chance.

Remedies and Future Steps

- Aggregate the six p-values, e.g., as $\sum \log p_i$ (Fisher, 1934), $\min\{p_i\}$ (Tippett, 1931), etc.
- Define cutoffs for these aggregated p-values to classify viewing patterns as *similar*, *somewhat different*, and *considerably different*.
- Use the aggregated p-values for multidimensional scaling.
- Investigate alternative options to compare viewing patterns, e.g., Jaccard index, applied to areas of interest in each posture.
- **Keep in mind: We want to determine similarity for participants from two groups and do not have to make a yes / no decision here.**

References

- Chetverikov, A., et al. (2018). Implicit processing during change blindness revealed with mouse-contingent and gaze-contingent displays. *Attention, Perception, & Psychophysics*, 80(4):844–859.
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- Tippett, L. H. C. (1931). *The Methods of Statistics*. London: Williams and Norgate, Ltd.

- **Questions !? —**

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